

What is claimed is:

1. A circulating system for circulating a fluid from a fluid source near a substantially tubular shaped conductor, the circulating system comprising:

5 a circulation housing that is sized and shaped to substantially encircle the conductor and provide a fluid passageway between the circulation housing and the conductor; and

10 a fluid inlet into the fluid passageway, the fluid inlet being in fluid communication with the fluid source so that fluid from the fluid source is supplied to the fluid passageway.

15 2. The circulating system of claim 1 including a fluid guide that extends between the circulation housing and the conductor, the fluid guide supporting the conductor spaced apart from the circulation housing.

3. The circulating system of claim 1 including a fluid guide that guides the flow of the fluid in the fluid passageway so that the fluid flows around the conductor.

20 4. The circulating system of claim 3 wherein the fluid guide includes a first rail that is positioned in the fluid passageway, the first rail directing the flow of fluid in the fluid passageway.

25 5. The circulating system of claim 3 wherein the fluid guide includes a first rail and a second rail that are positioned in the fluid passageway, the rails cooperating to direct the flow of fluid in the fluid passageway over an outer perimeter, a top surface, a bottom surface and an inner perimeter of the conductor.

30 6. The circulating system of claim 5 wherein the fluid inlet is positioned to direct the fluid between the rails in the fluid passageway.

7. The circulating system of claim 1 wherein the circulation housing includes a housing outer shell that encircles the conductor.

8. The circulating system of claim 7 wherein the circulation housing includes a housing inner shell that is sized and shaped to be substantially encircled by the conductor.

5 9. The circulating system of claim 8 wherein the housing outer shell and the housing inner shell are substantially coaxial.

10 10. The circulating system of claim 1 wherein the fluid is used for cooling the conductor.

10 11. An actuator combination including a first core, a second core, a conductor, and the circulating system of claim 1.

15 12. The actuator combination of claim 11 wherein the first core is E shaped and the second core is I shaped.

13. A stage assembly including the actuator combination of claim 11.

20 14. An exposure apparatus including the actuator combination of claim 11.

15. An object on which an image has been formed by the exposure apparatus of claim 14.

25 16. A semiconductor wafer on which an image has been formed by the exposure apparatus of claim 14.

17. An actuator combination for use with a fluid source including a fluid, the actuator combination comprising:

a first core;

a substantially tubular shaped conductor; and

5 a circulating system that circulates the fluid, the circulating system including (i) a circulation housing having a tubular shaped, housing cavity which receives the conductor and provides a fluid passageway between the circulation housing and the conductor, and (ii) a fluid inlet into the fluid passageway, the fluid inlet being in fluid communication with the fluid source  
10 so that fluid from the fluid source can be supplied to the fluid passageway.

18. The actuator combination of claim 17 including a fluid guide that extends between the circulation housing and the conductor, the fluid guide supporting the conductor spaced apart from the circulation housing.

19. The actuator combination of claim 17 including a fluid guide that guides the flow of the fluid in the fluid passageway so that the fluid flows around the conductor.

20. The actuator combination of claim 17 wherein the fluid guide includes a first rail and a second rail that are positioned in the fluid passageway, the rails cooperating to direct the flow of fluid in the fluid passageway over an outer perimeter, a top surface, a bottom surface and an inner perimeter of the conductor.

21. The actuator combination of claim 17 wherein the circulation housing includes a housing outer shell that encircles the conductor, and a housing inner shell that is sized and shaped to be substantially encircled by the conductor, wherein the outer shell and the inner shell are substantially coaxial.

22. The actuator combination wherein the first core is E shaped and the conductor substantially encircles a portion of the first core.

23. A stage assembly including the actuator combination of claim 17.

24. An exposure apparatus including the actuator combination of claim 17.

25. An object on which an image has been formed by the exposure apparatus of claim 24.

26. A semiconductor wafer on which an image has been formed by the exposure apparatus of claim 24.

27. A method for cooling a substantially tubular shaped conductor, the method comprising the steps of:

providing a circulation housing including a tubular shaped housing cavity that receives the conductor and defines a fluid passageway between the circulation housing and the conductor;

positioning the conductor in the housing cavity; and

directing a fluid through the fluid passageway to cool the conductor.

28. The method of claim 27 including the step of positioning a fluid guide between the conductor and the circulation housing, the fluid guide maintaining the conductor spaced apart from the circulation housing.

29. The method of claim 27 including the step of guiding the flow of fluid in the fluid passageway around the conductor with a fluid guide.

30. The method of claim 27 including the step of controlling the rate of flow of the fluid so that an outer surface of the circulation housing is maintained at a set temperature.

31. A method for making a circulating system adapted for use with a fluid from a fluid source for an attraction only type actuator including a conductor, the method comprising the steps of:

providing a circulation housing that is sized and shaped to substantially encircle the conductor and provide a fluid passageway between the circulation housing and the conductor; and

providing a fluid inlet into the fluid passageway in fluid communication with the fluid source so that the fluid from the fluid source can be supplied to the fluid passageway.

32. A method for making an exposure apparatus that forms an image on an object, the method comprising the steps of:

providing an irradiation apparatus that irradiates the object with radiation to form the image on the object;

5 providing an actuator as a driving force for moving the object; and

connecting the circulating system made by the method of claim 31 to the actuator.

33. A method of making an object utilizing the exposure apparatus made  
10 by the method of claim 32.

34. A method for making an actuator combination adapted for use with a fluid source including a fluid, the method comprising the steps of:

providing a first core;

15 providing a substantially tubular shaped conductor that encircles a portion of the first core; and

providing a circulating system including (i) a circulation housing that encircles the conductor and provides a fluid passageway between the circulation housing and the conductor, and (ii) a fluid inlet into the fluid passageway in fluid communication with the fluid source so that the fluid from  
20 the fluid source can be supplied to the fluid passageway.

35. A method for making an exposure apparatus that forms an image on an object, the method comprising the steps of:

25 providing an irradiation apparatus that irradiates the object with radiation to form the image on the object; and

providing an actuator combination made by the method of claim 34.

36. A method of making an object utilizing the exposure apparatus made  
30 by the method of claim 35.